LAr Purity Demonstrator

Brian Rebel

November, 2009

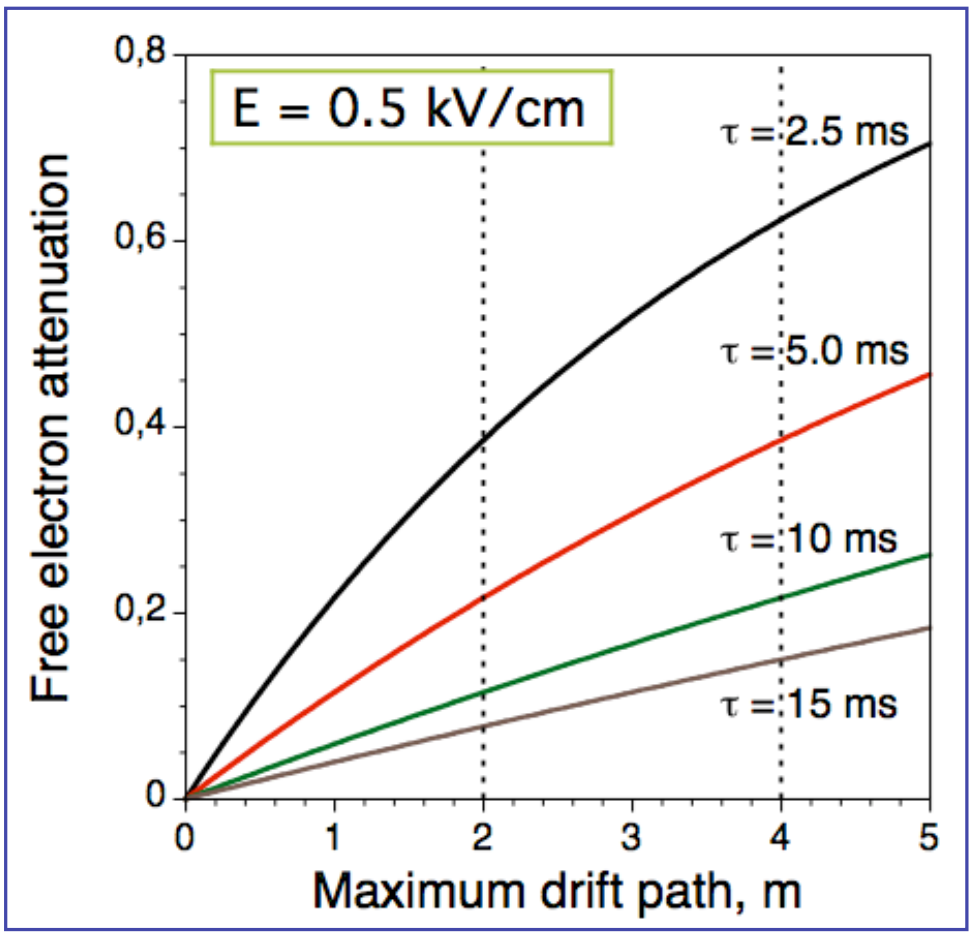
Outline

- Description of LAPD
- Goals of the project
- Status and timeline

LAPD group is M. Adamowski, W. Jaskierny, H. Jostlein, R. Plunkett, B. Rebel, R. Schmitt, E. Skup, T. Tope, T. Yang

Why LAPD?

- All LAr devices need to remove electronegative contaminants in a manner that keeps costs low
- Plot at right shows curves for electron attenuation as function of drift distance
- Want to keep the attenuation to be less than ~ 20% over the drift distance
- Need τ = 5 ms for 2 m drift distance, or about 0.06 ppb O_2 equivalent contamination



From C. Montanari, June 2007

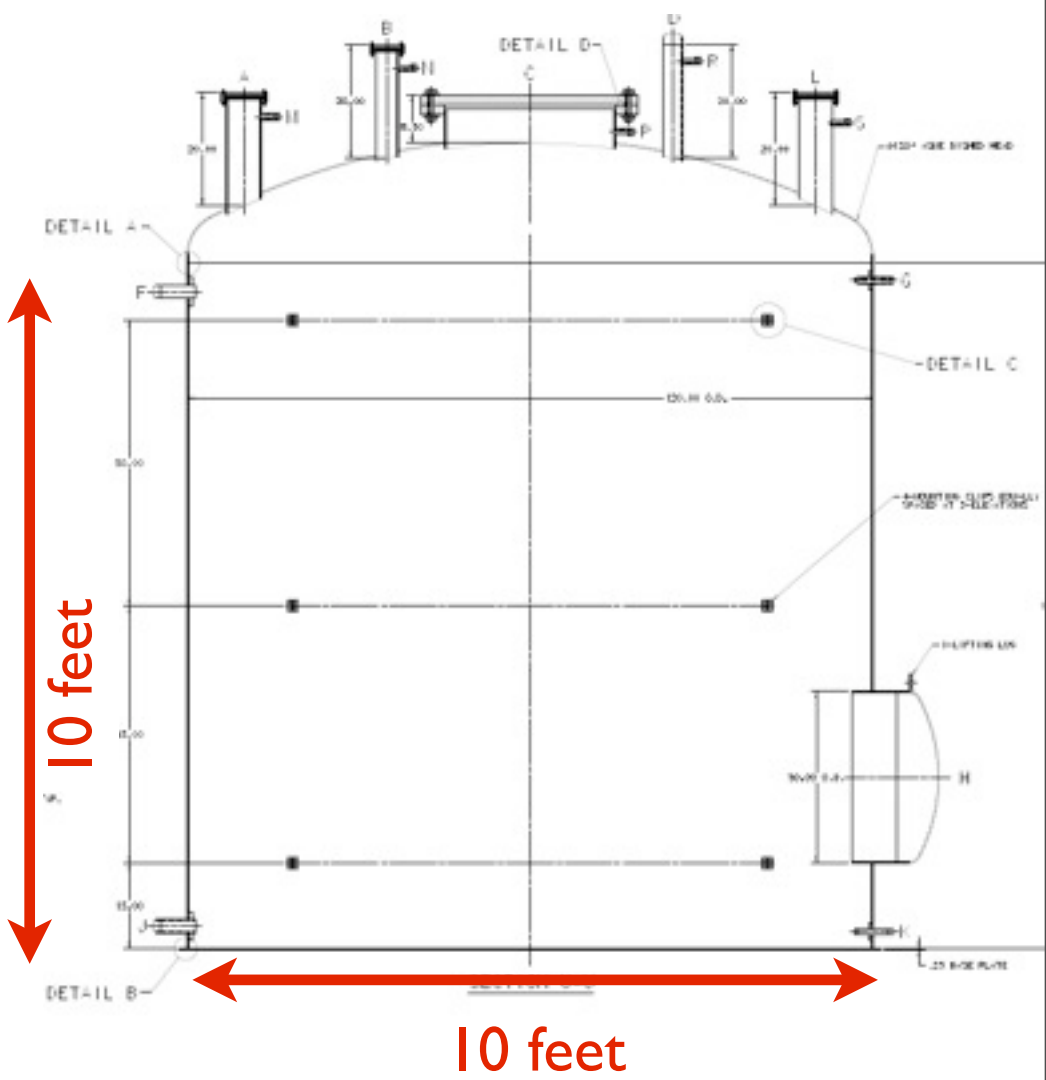
Purification Procedure from ICARUS

- Use ultra high vacuum standards for designing detector components, cleaning and construction
- Remove air and outgassed molecules from surfaces by evacuating the vessel volume to < 10^{-3} mbar
- Cool the volume quickly to mitigate the outgassing with argon purified through chemical filters and molecular sieves
- Recirculate the gas to block diffusion of impurities from hot regions or micro-leaks into the bulk liquid
- Recirculate the bulk liquid to actively remove impurities

This step is not necessarily scalable

Enter LAPD

- Current systems such as test stands at FNAL and ArgoNeuT use evacuation as the first cleaning step
- Building large vessels that can be evacuated is very expensive - scales the cost by a factor of 2
- Need to find an alternative to evacuation for large vessels
- LAPD is test stand at FNAL to study alternatives - vessel will hold ~ 30 t of liquid argon
- Vessel is 3/16 inch thick stainless steel

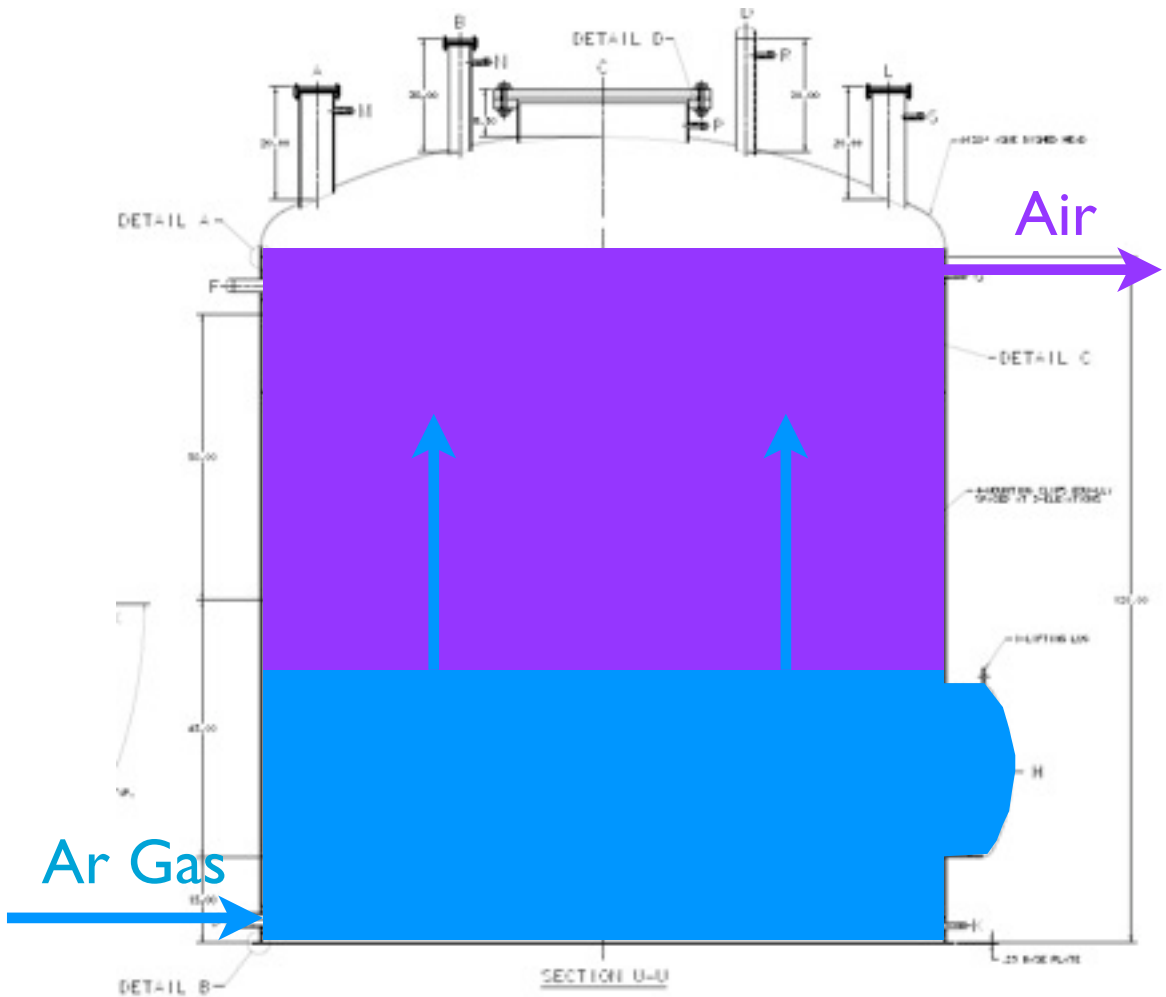


LAPD Goals

- Primary goal is to show that required electron lifetimes can be achieved without evacuation in an empty vessel - Phase I
- Will also monitor temperature gradients and convective flows, concentrations of water, O_2, and possibly N_2
- Phase II will place materials that would be used in a TPC into the volume and show that the lifetime can still be achieved
- Possible Phase III upgrade could place an actual TPC in the volume to provide a test bed for electronics, light collection, etc

Phase I - Purification without Evacuation

- Basic idea is to use an argon piston for initial purification
- Cycle a few volumes of clean, warm Ar gas through the volume to push out ambient air and dry out surfaces
- Then recirculate the gas through filter system to achieve < 50 ppm contamination



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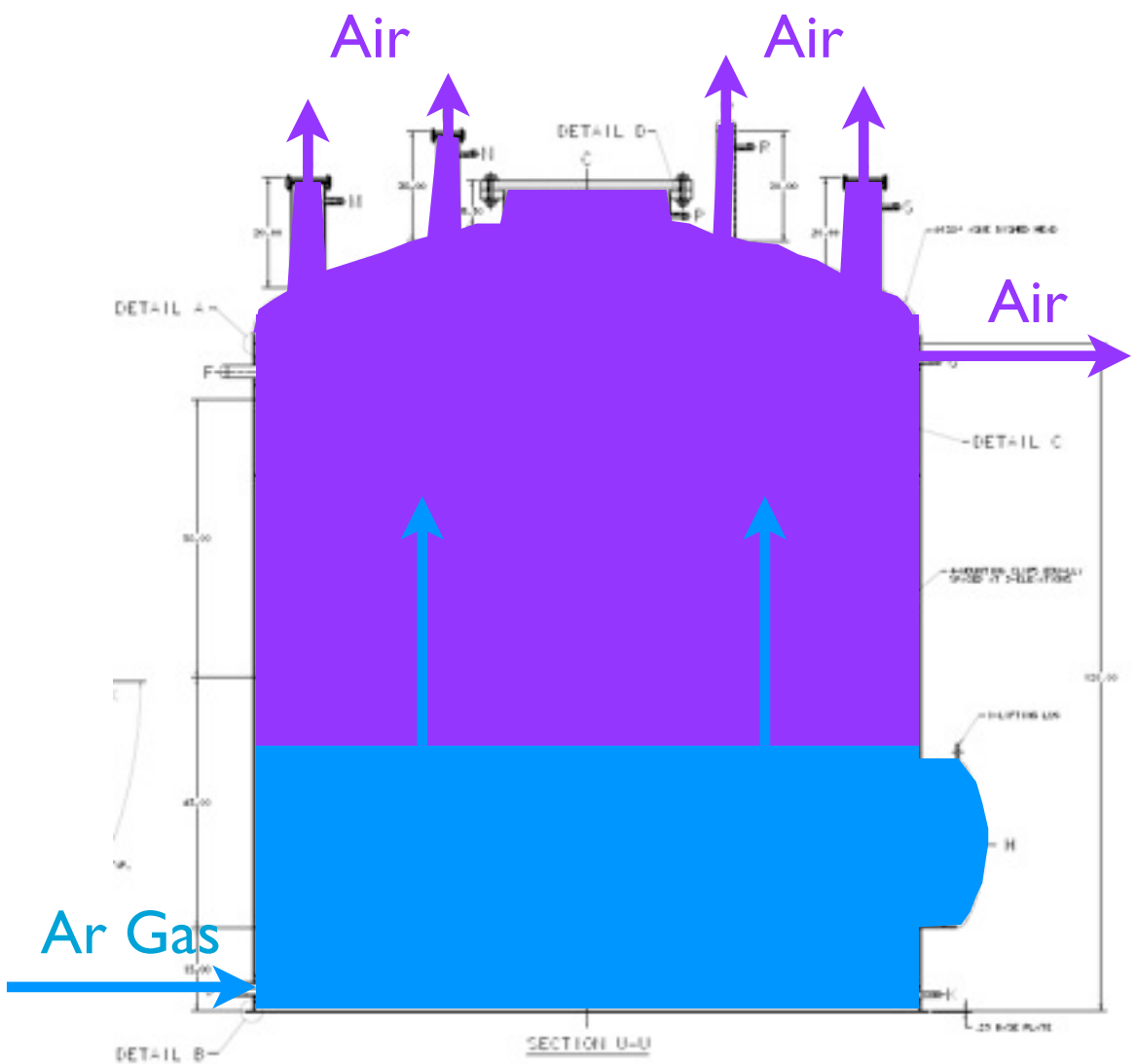

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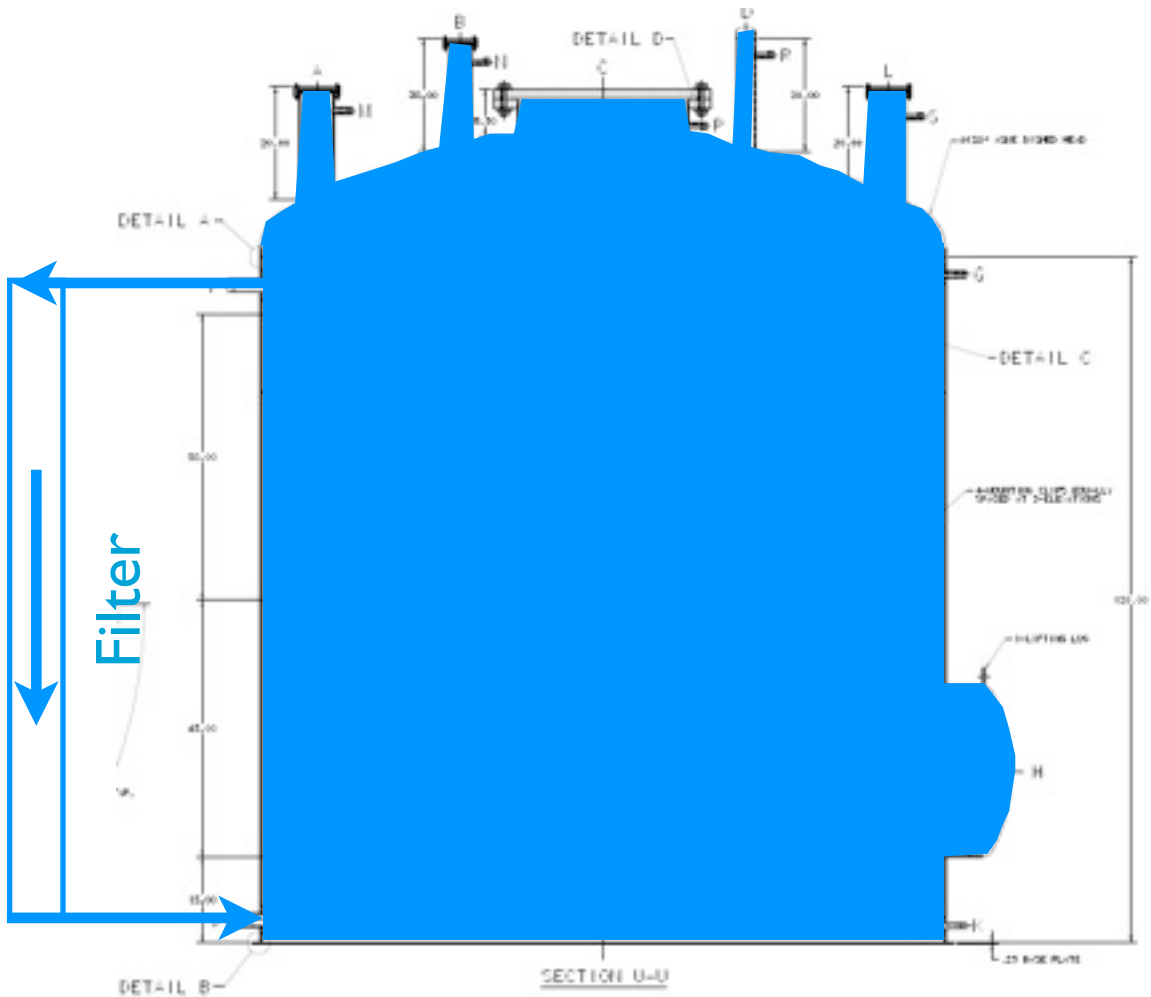
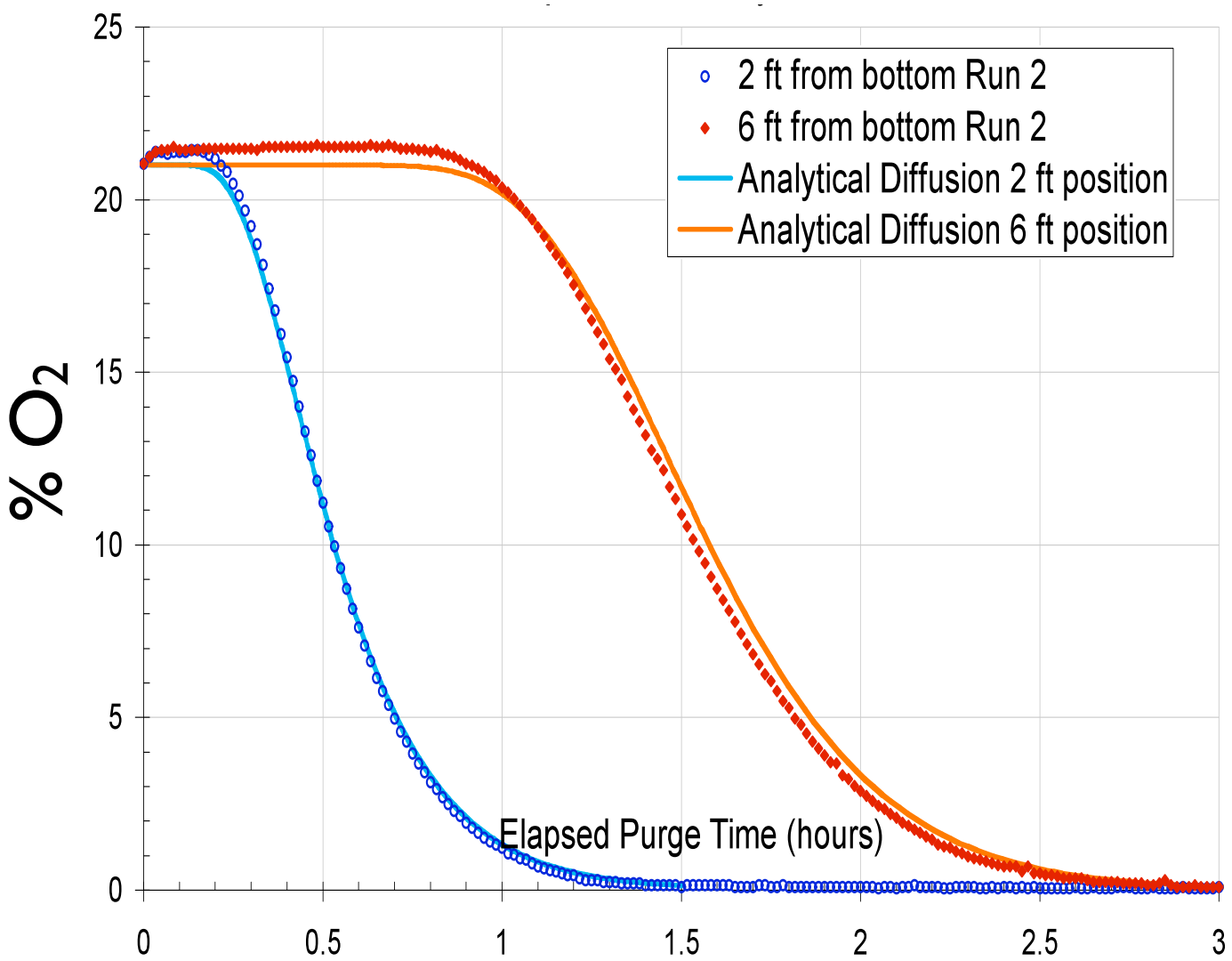
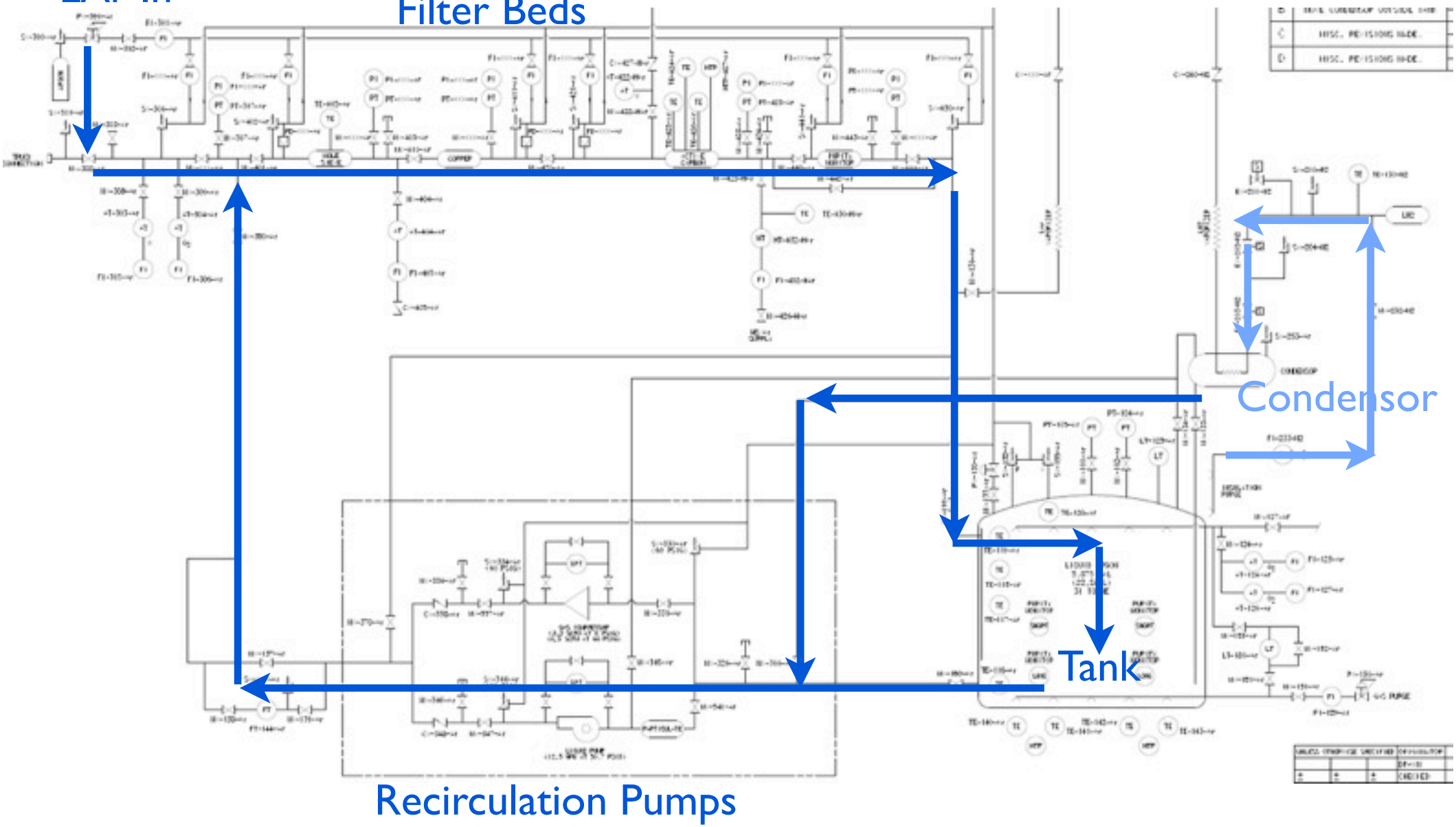


Number of Gas Volume Exchanges

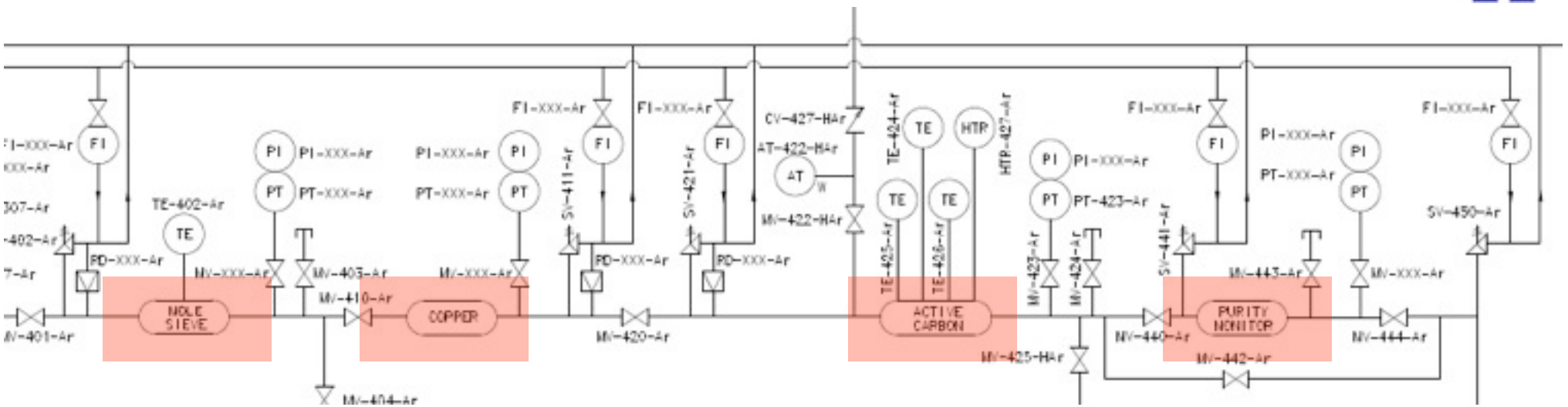


- Study by T. Tope at FNAL shows it takes 2.6 volume exchanges to reduce contaminants to 100 ppm

System Flow

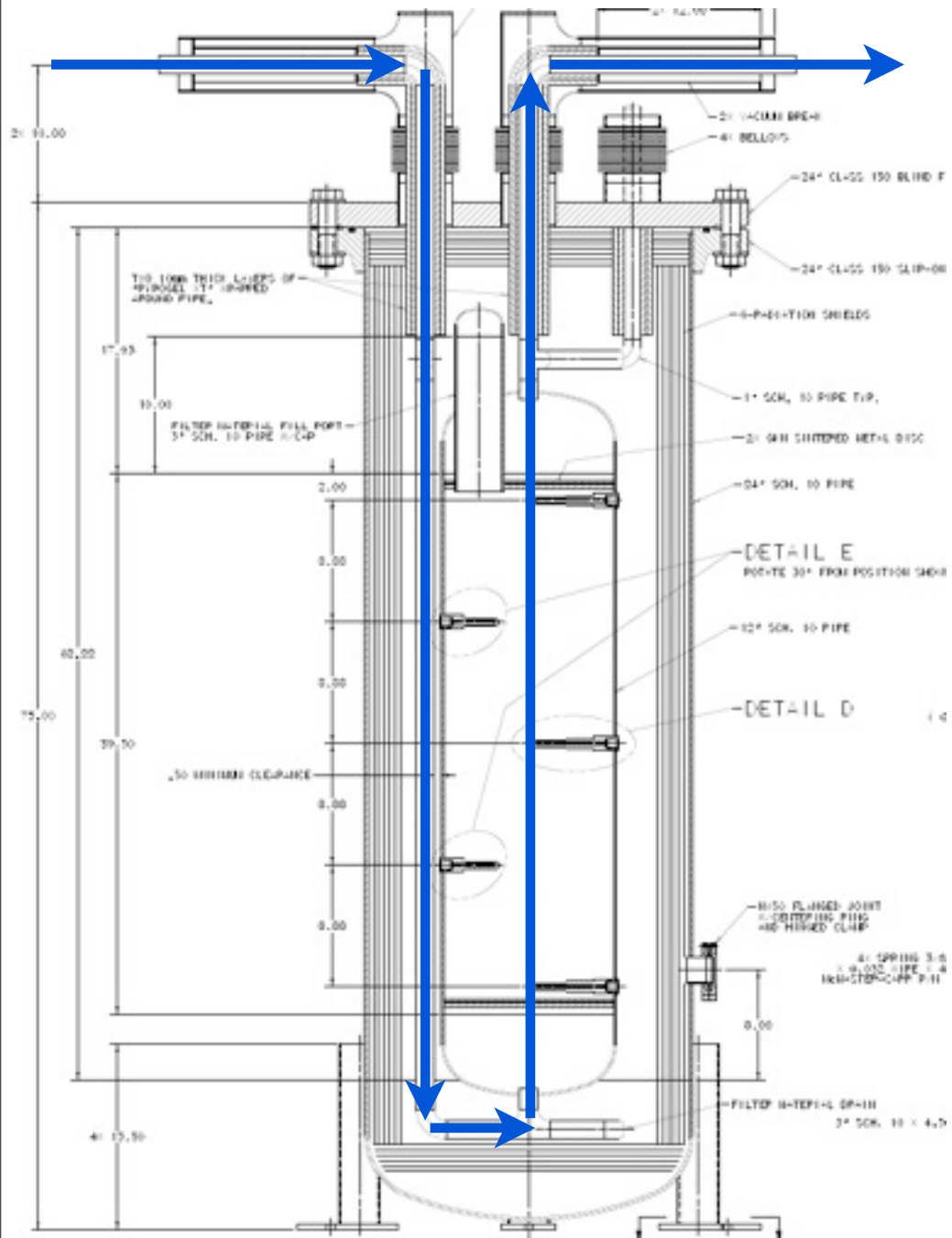


Filter System



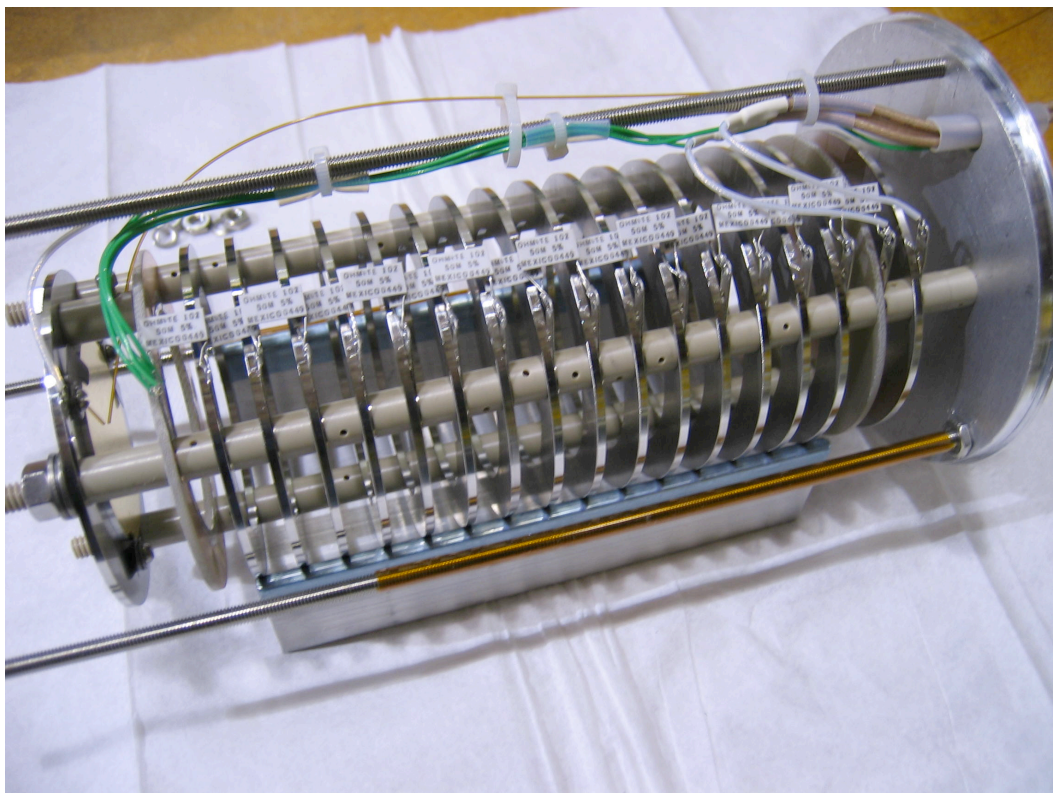
- 3 filters -
  - Molecular sieve - removes water
  - Copper removes O2
  - Active carbon removes hydrocarbons and miscellaneous contaminants
- Inline purity monitor to measure electron lifetime before passing liquid into rest of the system
- Inline water and O_2 monitors to measure contamination level

Filter Vessel



- 6 feet tall, 2 feet diameter
- Vacuum and mechanically insulated
- Liquid pushed through filter material from bottom
- Ports for heaters to regenerate the filters

Purity Monitor

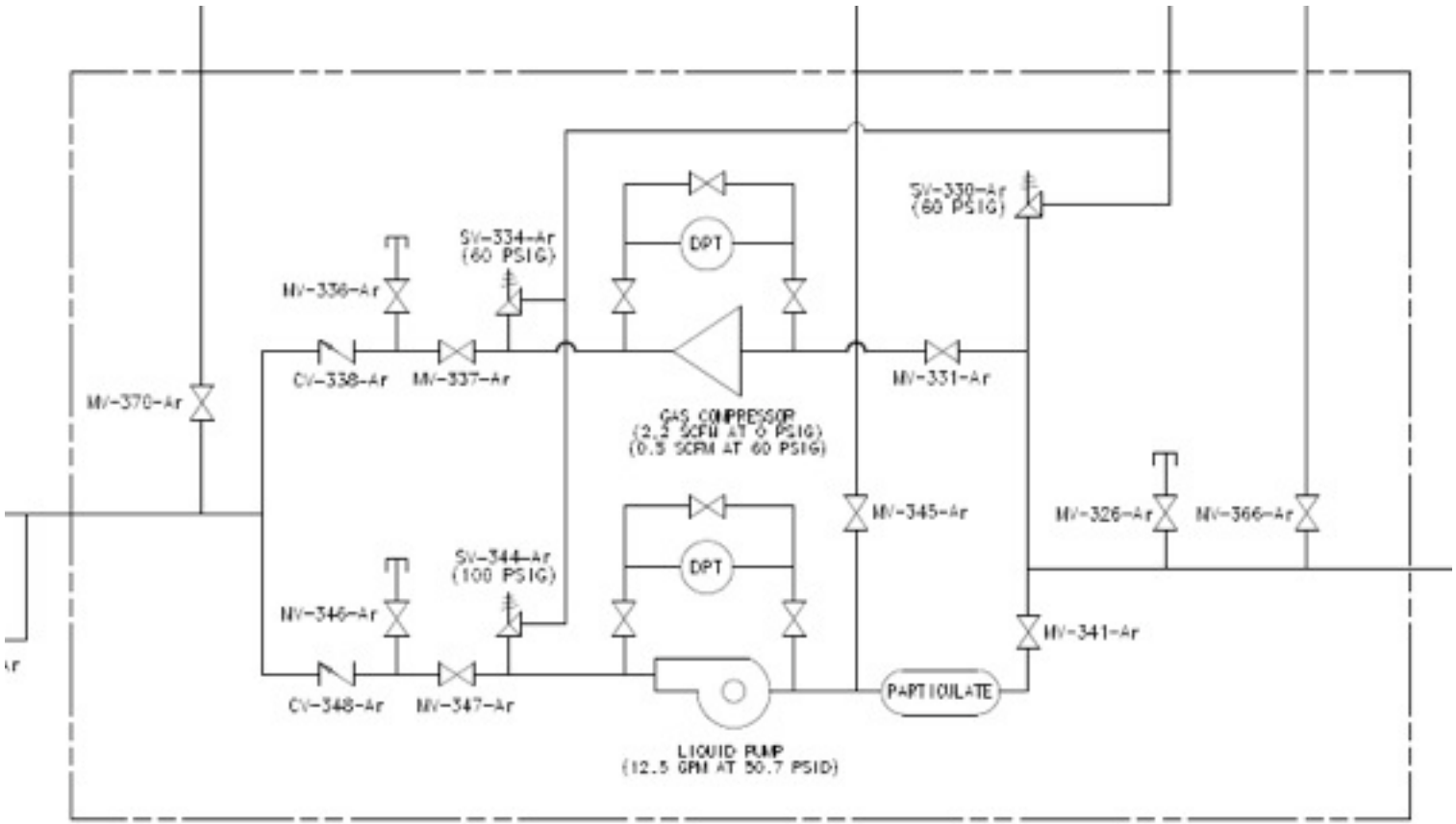


- Based on ICARUS design, same as used by MTS
- 20 cm long, provides initial go/no go on delivered argon
- Operated with same electric field as expected in detector - 500 V/cm
- Can adjust field to simulate longer drift distances

Water and O_2 Monitor

- TigerOptics Halo analyzer - vetted by MTS operations
- Detection at level of 0.3 ppb
- Uses laser to measure absorption from water in the sample
- O_2 monitor adds H to sample to make water

LAr Pump



- Gas compressor for recycling gaseous argon
- Liquid pump will exchange 2 volumes per day
- Particulate filter before liquid reaches the pump

LAr Flow Inside Vessel

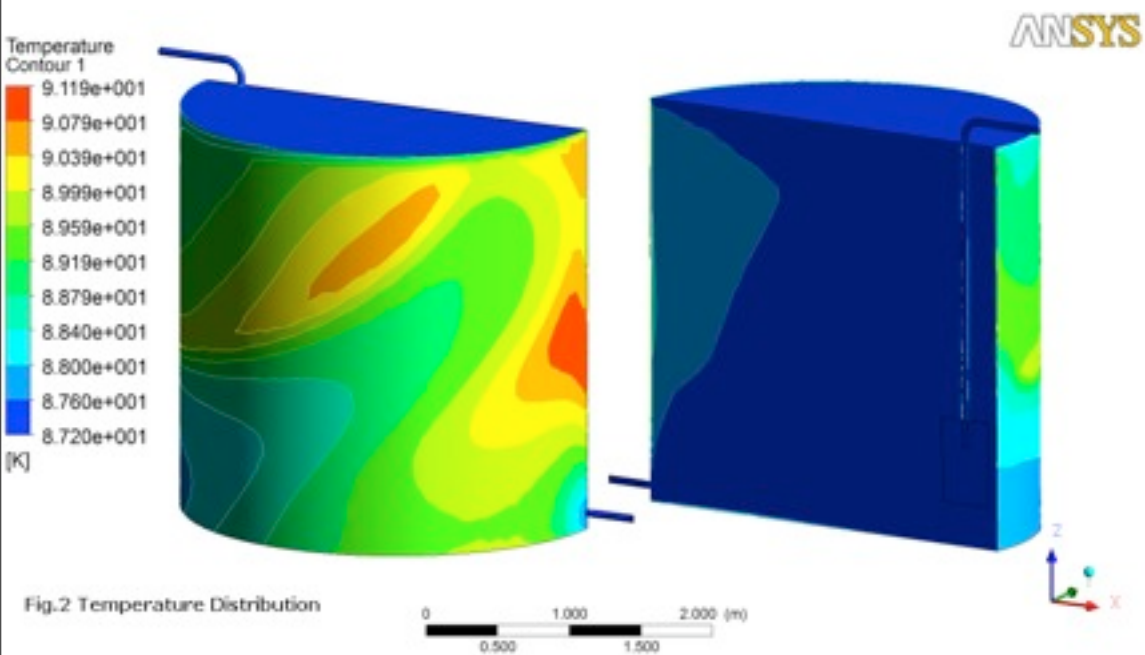


Fig.2 Temperature Distribution

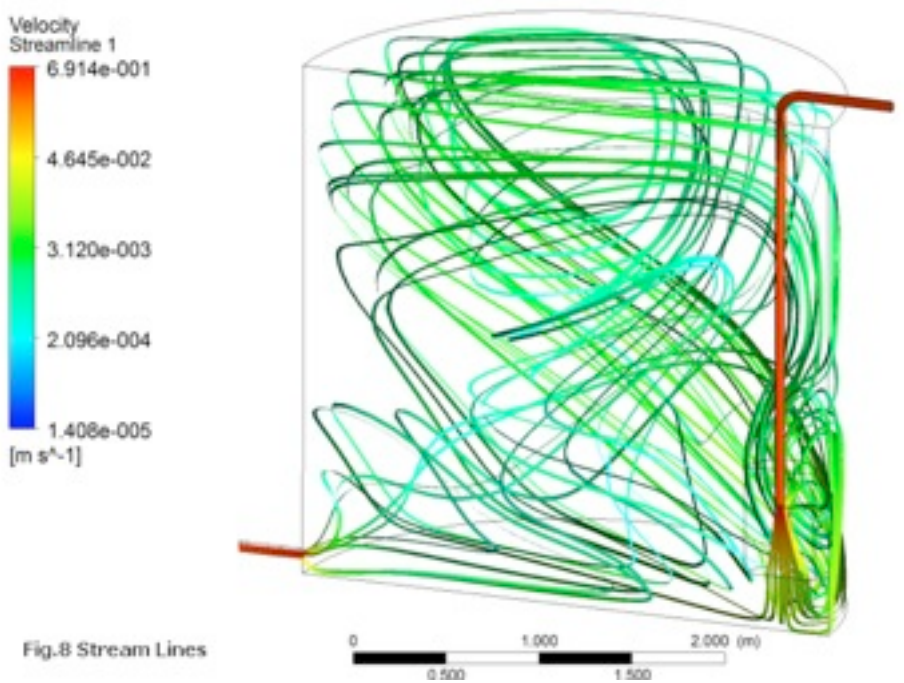
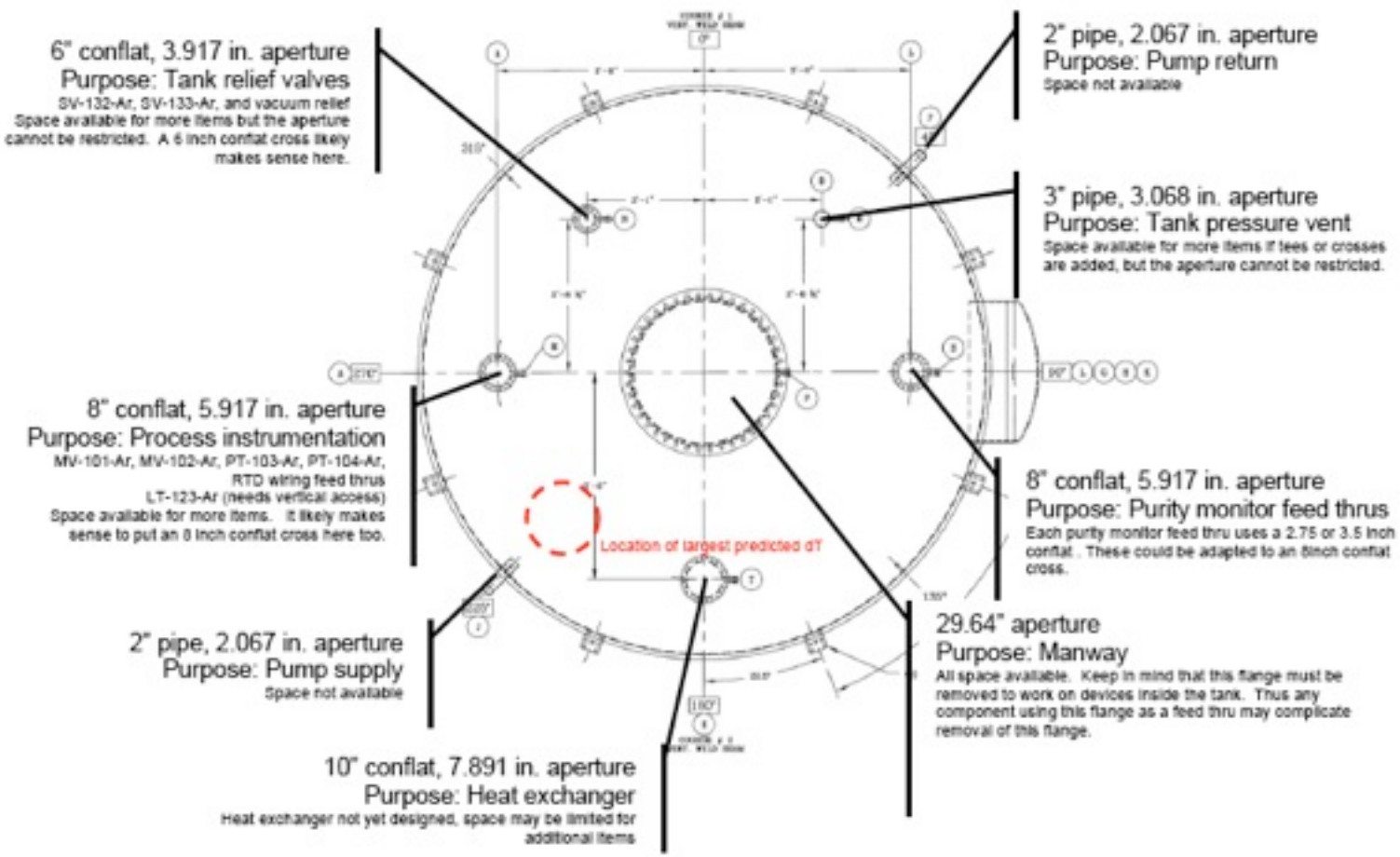


Fig.8 Stream Lines

- ANSYS modeling of temperature and flow in vessel done by Z. Tang
- Max temperature difference on surface of vessel is 2 degrees
- Hot spot on surface due to low flow in that region

Vessel Instrumentation



- 5 conflat ports available for instrumentation
- 4 purity monitors located in different areas, 20 cm and 50 cm long
- Temperature sensors used to monitor temperature at different depths, locations

The LAPD Tank

- Tank delivered September 1, 2009
- Placed in PC4 - in fixed target land at FNAL, where the Υ was discovered

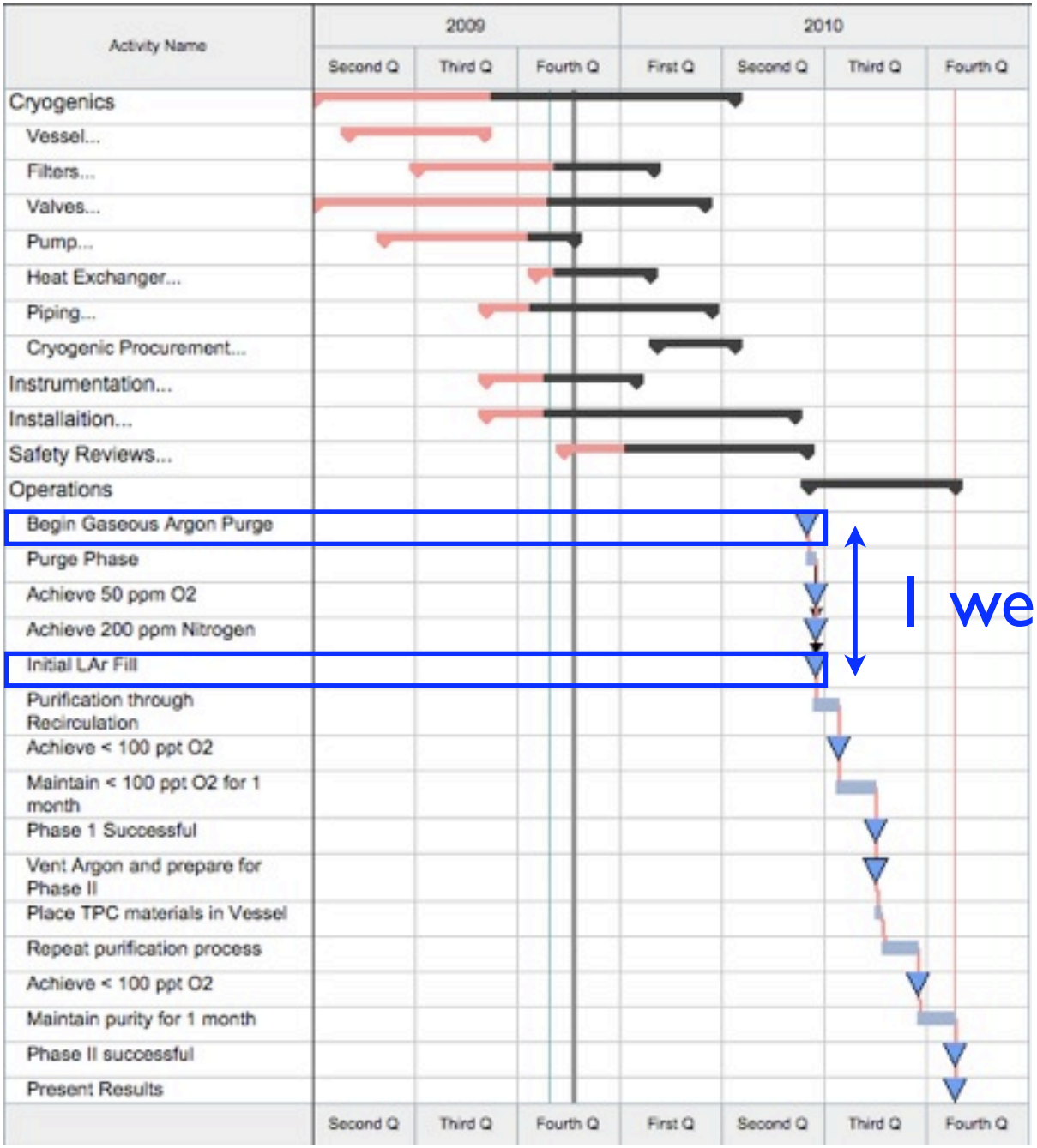
The LAPD Tank

- Tank resting on insulated platform
- Remaining insulation placed after instrumentation is completed

Schedule

- Time is of the essence - intend to complete Phase I by next summer
- Design of several components is at the > 80% level
  - Filter vessel, tank, pump all designed or delivered
  - Purity monitors and their electronics at 90% completion
  - Control system and temperature monitors will be designed based on MTS experience
- On-going major items include piping layout, valve procurement, heat exchanger and access platform design
- Next major items are installation and integration, ODH analysis, safety analysis by lab committee, and operations

Schedule


Activity Name
2009
2010
Second Q
Third Q
Fourth Q
First Q
Second Q
Third Q
Fourth Q
Cryogenics
Vessel...
Filters...
Valves...
Pump...
Heat Exchanger...
Piping...
Cryogenic Procurement...
Instrumentation...
Installaition...
Safety Reviews...
Operations
Begin Gaseous Argon Purge
Purge Phase
Achieve 50 ppm O2
Achieve 200 ppm Nitrogen
Initial LAr Fill
Purification through Recirculation
Achieve < 100 ppt O2
Maintain < 100 ppt O2 for 1 month
Phase 1 Successful
Vent Argon and prepare for Phase II
Place TPC materials in Vessel
Repeat purification process
Achieve < 100 ppt O2
Maintain purity for 1 month
Phase II successful
Present Results
1 week

Conclusions

- LAPD has dedicated team of engineers, technicians and physicists
- Team members have prior experience with MTS operations
- Tank is in place at FNAL, designs of cryogenics system is converging
- Expect to start tests in late spring 2010, first results by end of the summer 2010